

## DEPARTMENT OF ZOOLOGY SYLLABUS

M.Sc. course will be of four semesters with Special paper in Fish Biology. Each semester will have six (6) theory papers of 50 Marks each, two Practicals of 50 Marks each and one Seminar along with Dissertation of 50 Marks (25 Marks for presentation of seminar and 25 Marks for dissertation).

Each paper will contain 5 questions of 50 marks. The Q. No. 1 will be of 10 marks, short answer type (maximum 20 words) having 10 parts and covering entire syllabus. Q. No. 2 to 5, one from each unit with internal choice, will be long answer type (10 marks each).

### Semester-I

M.Sc. Zoology

#### Paper I. Non Chordata-I

Max. Mark 50

#### Unit-I

1. Protozoa.
  - 1.1 Locomotion and Nutrition in Protozoa
  - 1.2 Nucleus and Reproduction in Protozoa.

#### Unit-II

2. Theories and Origin of Metazoa.
3. Organization of coelom
  - 3.1 Pseudocoelomate
  - 3.2 Eucoelomate (Proterostomia and Deuterostomia)
4. Canal system & reproduction in Porifera.

#### Unit-III

5. Polymorphism in Siphonophora.
6. Coral and coral reefs.
7. Larval forms of Trematoda and Cestoda.

#### Unit-IV

8. General organization and affinities of Ctenophora, Rotifera, Phoronida, Sipunculida.

#### *Books Recommended*

1. Barnes: Invertebrate Zoology (4th ed 1980, Holt-Saunders International)
2. Barnes: The Invertebrates – A synthesis (3rd ed 2001, Blackwell)
3. Hunter: Life of Invertebrates (1979, Collier Macmillan)
4. Marshall: Parker & Haswell Text Book of Zoology, Vol. I (7th ed 1972, Macmillan)
5. Moore: An Introduction to the Invertebrates (2001, Cambridge University Press)
6. Harvey et al: The Vertebrate Life (2006)

**Semester- I**  
M.Sc. Zoology  
**PaperII. Biochemistry**

Max. Mark 50

**UNIT-I**

1. Bioenergetics
  - 1.1 Elementary ideas of thermodynamics
  - 1.2 Concept of free energy and calculations based on free energy change
  - 1.3 Biological Oxidation-reduction and Redox potential
  - 1.4 High energy phosphate compounds
2. Protein
  - 2.1 Primary structure (peptide bond)
  - 2.2 Secondary structure
    - 2.2.1  $\alpha$  -helix,  $\beta$  -pleated sheet and bends
    - 2.2.2 Prediction of secondary structure, Ramachandran plot
  - 2.3 Tertiary structure
    - 2.3.1 Forces stabilizing tertiary structure
    - 2.3.2 Domains and motifs
  - 2.4 Quaternary structure
  - 2.5 Determination of Primary structure
    - 2.5.1 Amino acid composition
    - 2.5.2 N- and C- terminal determination
    - 2.5.3 Amino acid sequence determination

**UNIT-II**

3. Carbohydrate (metabolic pathways)
  - 3.1 Glycolysis
  - 3.2 Krebs' s cycle
  - 3.3 Pentose phosphate pathway
  - 3.4 Glycogenesis, glycogenolysis and gluconeogenesis

**UNIT-III**

4. Lipids
  - 4.1 Fatty acid: biosynthesis and degradation ( $\beta$ -Oxidation)
  - 4.2 Eicosanoids biosynthesis and function (prostaglandins, thromboxanes and leukotrienes)
5. Enzymes
  - 5.1 Nomenclature and classification
  - 5.2 Isozyme, Ribozyme, Abzyme and Allozyme
  - 5.3 Multienzyme complexes

**UNIT-IV**

6. Enzyme kinetics
  - 6.1 Lowering energy of activation
  - 6.2 Single substrate reactions: steady state and equilibrium kinetics
  - 6.3 Derivation of Michaelis-Menten equation, related calculations And Michaelis-Menten plot
  - 6.4 Linear kinetic plots: Lineweaver-Burk, Edie-Hofstee, Hans-Wolf
7. Enzyme regulation and inhibition
  - 7.1 Allosterism
  - 7.2 Precursor activation and end product inhibition

7.3 Competitive; non-competitive; un-competitive inhibition

7.4 Determination of nature of inhibition by Lineweaver-Burk plot

Books recommended:

1. L. Stryer: Biochemistry, 5th Edition, (2002) Freeman &Co. New York
2. Berg et al: Biochemistry (5th ed 2001, Freeman)
3. Nelson et al: Lehninger Principles of Biochemistry (3rd ed 2004, Pearson)
4. Mathews et al: Biochemistry (3rd ed 1990, Benjamin/Cummings)
5. Zubay et al: Principles in Biochemistry (2nd ed 1995, WCB)
6. Murray et al: Harper's Illustrated Biochemistry (27th ed 1989, Appleton & Lange)
7. Goldsby et al: Kubey Biochemistry (2001, Freeman)
8. Voet and Voet: Biochemistry (2004, John Wiley)

**Semester -I**  
M.Sc. Zoology  
**Paper III. Cell Biology**

Max. Mark 50

UNIT-I

1. Prokaryotes

1.1 Viruses: structure and reproduction

1.1.1 Bacteriophage (Lambda phage)

1.1.2 Animal DNA virus (SV 40)

1.1.3 Retroviruses (HIV)

1.2. Bacteria

1.2.1 Structure and reproduction of *E. coli*

UNIT-II

2. Eukaryote

2.1 Nucleolus: structure and biogenesis of ribosome

2.2 Mitochondria

2.3.1 Structure: assemblies of respiratory chain and F<sub>0</sub>- F<sub>1</sub> ATP Synthase

2.3.2 Oxidative phosphorylation: mechanism and chemi-osmotic concept

2.3 Apoptosis: general mechanism and significance

UNIT -III

3. Cell cycle and its regulation

3.1 Overview and regulation of cell cycle

3.2 Cancer cell

UNIT-IV

4 Protein targeting, sorting and intracellular vesicular traffic

4.1 Transport of molecules into and out of the nucleus

4.2 Transport of proteins into mitochondria and peroxisomes

4.3 Signal hypothesis, signal peptide and SRP dependent targeting of translational complex

4.4 Transport from ER through Golgi apparatus

4.5 Transport from trans Golgi to lysosomes

4.6 Exocytosis and Endocytosis

*Books Recommended*

1. Alberts et al: Essential Cell Biology (1998, Garland)
2. Alberts et al: Molecular Biology of the Cell (4th ed 2002, Garland)
3. Lodish et al: Molecular Cell Biology (6th ed 2007, Freeman)
4. DeRobertis & DeRobertis: Cell and Molecular Biology (1987, Lee & Febiger)
5. Pollard & Earnshaw: Cell Biology (2002, Saunders)
6. Karp: Cell and Molecular Biology (2002, John Wiley & Sons)
7. DeRobertis & DeRobertis: Cell and Molecular Biology (1987, Lee & Febiger)

**Semester-I**  
M.Sc. Zoology  
**Paper IV. Environmental Biology**

Max. Mark 50

UNIT-I

1. Ecological principles
  - 1.1 Concept of ecosystem
  - 1.2 Food chains and Food webs
  - 1.3 Ecological pyramids
2. Ecological Energetic
  - 2.1 Concepts of Productivity
  - 2.2 Energy flow in ecosystem
    - 2.2.1 Simplified Energy flow model
    - 2.2.2 Universal Energy flow model
    - 2.2.3 Y-shaped Energy flow model

UNIT-II

3. Environmental factors
  - 3.1 Abiotic factors (Temperature, light and relative humidity)
    - 3.1 Concept and laws of limiting factors
  - 3.2. Biotic factors with special reference to Intra- and Inter-specific relationship

UNIT-III

4. Population ecology
  - 4.1 Density
  - 4.2 Natality
  - 4.3 Mortality
  - 4.4 Survivorship
  - 4.5 Age distribution
  - 4.6 Growth curve, growth form and carrying capacity
  - 4.7 Aggregation, dispersal and their regulation

UNIT-IV

5. Environment and human health
  - 5.1 Environmental pollutants
    - 5.1.1 Degradable Non degradable
  - 5.2 Air, water and noise pollution
6. Radiation ecology; an overview

*Books recommended*

1. Cunningham and Saigo: Environmental Science (5th Ed., McGraw Hill, 1999).
2. Odum : Fundamentals of Ecology (Saunders, 1971).
3. Odum and Baret: Fundamentals of Ecology (EWP, 2005).
4. Primark : A Primer of Conservation Biology (2nd Ed., Sinauer, 2004).
5. Raven, Berg, Johnson: Environment (Saunders. 1993).
6. Sharma: Ecology and Environment (7th Ed., Rastogi, 2000).
7. Turk and Turk: Environmental Science (4th Ed., Saunders, 1993).
8. Wright and Nebel: Environmental Science (8th Ed., Prentice Hall, 2002).

**Semester-I**  
M. Sc. Zoology  
**Paper V. Genetics**

Max. Mark-50

UNIT-I

1. Gene mapping
  - 1.1 3-point test cross in *Drosophila*
  - 1.2 Tetrad analysis in *Neurospora*
  - 1.4 Gene mapping in bacteria (conjugation, transformation and transduction)

UNIT-II

- 2.1 Eukaryotic chromatin structure and chromosome organization
  - 2.1.1 Chromosomal protein: Histone and non-histone
  - 2.1.2 Mitotic metaphase chromosome
  - 2.1.3 Centromere , kinetochore, telomere, satellite
- 2.2. Mutation
  - 2.2.1 Basic features of mutation
  - 2.2.2 Types: Spontaneous and induced
  - 2.2.3 Molecular basis of mutation
  - 2.2.4 Detection of mutation
    - 2.2.4.1 Nutritional mutation in *Neurospora*,
    - 2.2.4.2 X- linked recessive lethal mutation in *Drosophila*
  - 2.2.5 Effects of mutation in human
    - 2.2.5.1 Human globin gene (sickle cell hemoglobin)
    - 2.2.5.2 Blocks in metabolic pathway- phenylketonuria, albinism, alkaptonuria
    - 2.2.5.3 Reciprocal translocation: chronic myelogenous leukemia and burkitt's

lymphoma

UNIT-III

3. Developmental genetics
  - 3.1 *Caenorhabditis elegans*
    - 3.1.1 Genetics of embryonic development
    - 3.1.2 Sex determination
  - 3.2 *Drosophila*
    - 3.2.1 Genetics of embryonic development
      - 3.2.1.1 Maternal gene activity: Formation of axis
      - 3.2.1.2 Zygotic gene activity: Homeotic gene, segmentation gene, pair rule genes, segment polarity genes
    - 3.2.2 Sex determination in *Drosophila*
  - 3.3 Organization of HOX gene in vertebrates

Unit-IV

- 4.1 Extranuclear inheritance
  - 4.1.1 Maternal effects
  - 4.1.2 Organelle inheritance
  - 4.1.3 Infective inheritance
- 4.2 Polygene and inheritance of quantitative characters
- 4.3 Fine structure of gene: Benzer's analysis of rII locus

*Books Recommended:*

1. Gardner et al: Principles of Genetics (1991, John Wiley)
2. Griffith et al: Modern Genetic Analysis (2002, Freeman)
3. Hartl & Jones: Essential Genetics: A Genomic Perspective (2002, Jones & Bartlet)
4. Russell: Genetics (2002, Benjamin Cummings)
5. Snustad & Simmons: Principles of Genetics (2003, John Wiley)

**Semester-I**  
M.Sc. Zoology  
**Paper VI. Evolution and Systematics**

Max. Mark 50

UNIT-I

- 1.1 Origin of life
- 1.2 An overview of evolutionary concepts
- 1.3 Principles of synthetic theory

UNIT-II

- 2.1 Population genetics
  - 2.1.1 Gene frequencies in Mendelian population
  - 2.1.2 Hardy-Weinberg equilibrium
  - 2.1.3 Maintenance of genetic equilibrium
  - 2.1.4 Determination of allelic and genotypic frequency
- 2.2. Elemental forces of evolution
  - 2.2.1 Mutation
  - 2.2.2 Selection & selection coefficient
  - 2.2.3 Random genetic drift
  - 2.2.4 Migration

UNIT-III

- 3.1 Phylogenetic relationship
  - 3.1.1 Chromosome phylogeny in *Drosophila* (based on inversion polymorphism)
  - 3.1.2 Neutral theory
  - 3.1.3 Mitochondrial DNA phylogeny
- 3.2. Isolating mechanisms
- 3.3. Models of speciation: allopatric, sympatric, stasipatric

UNIT-IV

- 4.1 Concepts of species
- 4.2. Taxonomic characters and their variation
- 4.3. Procedures of classification

*Books Recommended*

1. Dobzhansky: Genetics and the Origin of Species (1964, Columbia)
2. Dobzhansky: Evolution 1976, ( 2004, Surjeet Publ.)
3. Freeman and Herron: Evolutionary Analysis (1998, Prentice Hall)
4. Futuyma: Evolutionary Biology (1998, Sinauer)
5. Hedrick: Genetics of populations (2005, Jones and Bartlett Publ Inc)
6. Hartl and Clark: Principles of Population Genetics (1989 & 1997, Sinauer)
7. Mayr: Animal Species and Evolution (1966, Belknap Press)
8. Ridley: Evolution (1993, Blackwell)
9. Strickberger: Evolution (2000, Jones and Bartlett)
10. White: Modes of Speciation (1978, Freeman)
11. Coyne and Orr: Speciation(2004, Sinauer)
12. Mader: Biology (2007, McGraw)
13. Mayr: Populations, Species and Evolution: An Abridgement of Animal Species and Evolution (1971, Belknap Press)
14. Moody (1978): Introduction to Evolution. (Kalyani Publ.)



## Semester -I

### Practical I. Non chordata and environmental biology

Max. Mark 50

Duration: 5 hrs

Dissection	..... 10
Preparation	..... 07
Environmental biology	.....08
Spots (5)	..... 10
Viva voce	..... 05
Records	..... 10

#### A. Non chordata

1. Study of slides and museum specimens of-
  - Protozoa
  - Porifera
  - Cnidaria
  - Helminths
2. Preparation of permanent slides-
  - *Paramecium*
  - Gemmule & spicules
  - *Obelia, Bougainvillea, Sertularia*
  - Jaw of leech
3. Dissection and display of-
  - Digestive system of leech
  - Reproductive system of leech

#### B. Environmental Biology

1. Study of ecological adaptations in selected specimens.
2. Determination of pH, % moisture content, carbonate, nitrate in soil sample.
3. Measurement of CO<sub>2</sub> content (acidity) in water.
4. Measurement of alkalinity (phenolphthelin method).
5. Measurement of O<sub>2</sub> content in water.
6. Measurement of hardness in water.

## Semester -I

### Practical II. Biochemistry and cytogenetics

Max. Mark 50  
Duration: 5 hrs

Biochemistry	..... 20
Cytogenetics	..... 15
Viva voce	..... 05
Records	..... 10

#### A. Biochemistry

1. Preparation of Standard curve for glucose & Verification of Beer's law
2. Estimation of glycogen in frog liver- colorimetric
3. Separation of amino acids by paper chromatography
4. Demonstration of two dimensional paper chromatography
5. Osmotic pressure
6. Study of urease activity
  - 6.1 Effect of enzyme concentration
  - 6.2 Effect of pH on enzyme activity
  - 6.3 Effect of time on enzyme activity
  - 6.4 Effect of substrate concentration on enzyme activity
  - 6.5 Determination of Km and Vmax by Michaelis-Menten and Lineweaver-Burk Plot

#### B. Cytogenetics

1. Micrometric measurement of blood corpuscles
2. Temporary squash preparation of polytene chromosomes from salivary glands of *Drosophila* larvae/ chironomous larvae
3. Smear technique to observe sex chromatin in buccal epithelial cells
4. Study of human karyotype from sheet
5. Estimation of frequency of common genetic traits in local human population
6. Numerical exercises based on use of Chi-square test to detect Linkage
7. Numerical exercise on determination of allelic and genotypic frequency
8. Demonstration of Hardy-Weinberg equilibrium in human populations by taking examples of ABO blood group system.

### 2. Practical III. Dissertation & Seminar

Max. Marks 50

Each student has to prepare a dissertation on semester based syllabus and present a seminar. This will be evaluated by a panel of internal examiners (time allotted for presentation is 45 minutes per student).

- |                |          |
|----------------|----------|
| - Dissertation | 25 Marks |
| - Seminar      | 25 Marks |

**Semester II**  
M.Sc. Zoology  
**Paper I. Non Chordata II**

Max. Mark 50

Unit-I

1. Organs of respiration: book lungs and tracheal system.
2. Organs of excretion and their function: flame cells, nephridia and Malpighian tubule.
3. Adaptive radiation in Polychaetes.

Unit-II

4. Primitive nervous system in Coelenterate and Echinodermata.
5. Nervous system in Annelida (Polychaeta), Arthropoda (Crustacea and Insecta) and Mollusca (Cephalopoda).
6. Torsion in Gastropoda.

UNIT-III

7. Trochophore larva : structure and significance
8. Larval forms in crustacean
9. Larval forms in Echinodermata

UNIT- IV

10. Mouth parts of insects
11. General organization and affinities of Onychophora
12. Affinities of Trilobites
13. Affinities of Echinodermata

*Books Recommended*

1. Barnes: Invertebrate Zoology (4th ed 1980, Holt-Saunders International)
2. Barnes: The Invertebrates – A synthesis (3rd ed 2001, Blackwell)
3. Hunter: Life of Invertebrates (1979, Collier Macmillan)
4. Marshall: Parker & Haswell Text Book of Zoology, Vol. I (7th ed 1972, Macmillan)
5. Moore: An Introduction to the Invertebrates (2001, Cambridge University Press)
6. Harvey et al: The Vertebrate Life (2006)

**Semester -II**  
M.Sc. Zoology  
**Paper II. Biostatistics**

Max. Mark 50

UNIT-I

1. Consolidation, diagrammatic and graphical presentation of data
2. Measures of Central Tendency
  - 2.1 Characteristics of satisfactory average
  - 2.2 Types of averages , their merits and demerits
  - 2.3 Mean
  - 2.4 Median
  - 2.5 Mode
  - 2.6 Weighted mean
  - 2.7 Geometric mean
  - 2.8 Harmonic mean

UNIT-II

- 3 Measures of Dispersion (Absolute and Relative measures)
  - 3.1 Range
  - 3.2 Quartile deviation
  - 3.3 Mean deviation
  - 3.4 Variance and Standard deviation
  - 3.5 Coefficient of variation and SEM
- 4 Analysis of variance (One way)

UNIT-III

- 5 Elementary idea of probability
- 6 Theoretical Distributions
  - 6.1 Normal
  - 6.2 Binomial
  - 6.3 Poisson

UNIT-IV

- 7 Null hypothesis and types of errors in testing hypothesis
- 8 Test Criterion (t- test, F-test, Chi-square test and its significance in genetical analysis)
- 9 Correlation and Regression (Simple)

Books recommended:

1. S.C. Gupta: Fundamentals of statistics (2004 ed., Himalaya Publ.)
2. J. H. Zarr: Biostatistical analysis (4<sup>th</sup> ed 2012, Pearson Publ.)
3. P.K. Banerjee: Introduction to Biostatistics (3<sup>rd</sup> ed.2006; S. Chand Publ.)
4. P.K. Banerjee: Problems on Genetics, molecular genetics and Evolutionary problems (2006, New Central book Agency,Kolkatta)

**Semester - II**  
M.Sc. Zoology  
**Paper III. Molecular Biology**

Max. Mark 50

UNIT-I

1. DNA
  - 1.1 Molecular architecture of DNA
  - 1.2 Denaturation and renaturation of DNA
  - 1.3 Classes of DNA sequences : Unique, middle, repetitive and highly repetitive (LINEs and SINEs)
2. DNA replication and DNA repair
  - 2.1 Semi conservative replication and apparatus in pro- and eukaryotes
  - 2.2 DNA repair mechanisms

UNIT-II

3. Types of RNA
4. Transcription
  - 4.1 Transcription in prokaryotes
  - 4.2 Transcription in eukaryotes
    - 4.2.1 Transcription factors: general and specific
    - 4.2.2 Assembly of pre-initiation complex and initiation
    - 4.2.3 Elongation and elongation factors

UNIT-III

5. Post transcriptional modification and processing of RNA
  - 5.1 Post transcriptional modification and processing of tRNA, rRNA and mRNA
  - 5.2 Self splicing in *Tetrahymena thermophila*
  - 5.3 RNA editing
6. Genetic Code
  - 6.1 Deciphering of genetic code
  - 6.2 Features of genetic code

UNIT-IV

6. Translation and post translational processing
  - 7.1 Translation in prokaryote
  - 7.2 Translation in eukaryote
  - 7.3 Post translational processing (with reference to Protein folding and molecular chaperons)
8. Regulation of gene expression
  - 8.1 Concept of Operon: Inducible and repressible systems
  - 8.2 Lac Operon structural organization and regulation
  - 8.3 Tryptophan Operon structural organization and regulation

*Books Recommended*

1. Boyer: Modern Experimental Biochemistry and Molecular biology (2nd ed 1993, Benjamin/Cumin)
3. Holme and Peck: Analytical Biochemistry (3rd ed 1998, Tata McGraw Hill)
7. Alberts et al: Molecular Biology of the Cell (2002, Garland)
8. Karp: Cell and Molecular Biology (2007, Wiley)

9. Lodish et al: Molecular Cell Biology (2007, Freeman)
1. Malacinski: Freifelder's Essentials of Molecular Biology (4th ed 2005, Narosa)
8. Lodish et al: Molecular Cell Biology (6th ed 2007, Freeman)
9. Goldsby et al: Kubey Biochemistry (2001, Freeman)
10. Gesteland et al: RNA World (2nd ed 1999, Cold Spring Harbor)

**Semester - II**  
M.Sc. Zoology  
**Paper IV. Biological tools & techniques**

Max. Mark 50

**UNIT-I**

1. Microscopy
  - 1.1 Principles of light microscope
    - 1.1.1 Compound microscope
    - 1.1.2 Phase contrast microscope
  - 1.2 Electron microscope
    - 1.2.1 TEM
    - 1.2.2 SEM
1. Spectrophotometry
  - 2.1 Basic concept and Absorption spectrum,
  - 2.2 Beer-Lambert's law,
  - 2.3 Principles and applications of colorimetry
  - 2.4 Visible and UV spectrophotometer

**UNIT-II**

2. Centrifugation
  - 3.1 Principles & concepts of centrifugation
  - 3.2 Types of rotors
  - 3.3 Clinical, high speed and ultracentrifuge
  - 3.4 Differential and density gradient centrifugation
4. Chromatography:
  - 4.1 Principles
  - 4.2 Paper and thin layer chromatography
  - 4.3 Column chromatography
    - 4.3.1 Gel filtration
    - 4.3.2 Ion exchange
    - 4.3.3 Affinity
  - 4.4 Introduction to HPLC

**UNIT-III**

5. Electrophoresis
  - 5.1 Principles
  - 5.2 Agarose gel electrophoresis
  - 5.3 Polyacrylamide gel electrophoresis (PAGE)
    - 5.3.1 Native PAGE,
    - 5.3.2 SDS-PAGE
  - 5.4 Isoelectrofocussing
  - 5.5 Two dimensional electrophoresis

**UNIT-IV**

6. Detection of proteins
  - 6.1 Western blotting and Dot blots
  - 6.2 ELISA
  - 6.3 Immunocytochemistry
7. Histochemical Techniques
  - 7.1 General principles of histochemical staining
  - 7.2 Histochemical localization of carbohydrate (PAS reaction)

7.3 Histochemical localization of Protein (Ninhydrin-Schiffs reaction)

7.4 Histochemical localization of general lipid (Sudan Black B)

7.5 Histochemical localization of enzyme (Phosphatases)

*Books Recommended*

1. Boyer: Modern Experimental Biochemistry and Molecular biology (2nd ed 1993, Benjamin/Cumin)
2. Freifelder: Physical Biochemistry ( 2nd ed 1982, Freeman)
3. Holme and Peck: Analytical Biochemistry ( 3rd ed 1998, Tata McGraw Hill)
4. Plummer: An Introduction to Practical Biochemistry (3rd ed 1990, Tata-McGraw Hill)
5. Switzer and Garrity: Experimental Biochemistry ( 92nd ed 1999, Freeman)
6. Wilson and Walker: Principles of Biochemical and Molecular Biological Techniques (6th ed 2006, Cambridge Univ Press)
7. Alberts et al: Molecular Biology of the Cell (2002, Garland)
8. Karp: Cell and Molecular Biology (2007, Wiley)
9. Lodish et al: Molecular Cell Biology (2007, Freeman)
10. Pollard & Earnshaw: Cell Biology (2002, Saunders)
11. Ruthman: Methods in Cell Research (1970, Bell & Sons)
12. Bancroft & Stevens: Theory and Practice of Histological techniques (2002, Churchill-Livingstone)
13. Casselman: Histochemical techniques (1959, John Wiley)
14. Pearse: Histochemistry: Theoretical and Applied (Vol. I, II & III) (4th ed 1980-1993, Churchill-Livingstones)



**Semester-II**  
M.Sc. Zoology  
**Paper V. Endocrinology**

Max. Mark 50

**UNIT-I**

1. Mechanism of hormone action
  - 1.1 Protein hormones
    - 1.1.1 Membrane receptors
    - 1.1.2 G-proteins
    - 1.1.3 Cyclic AMP signalling cascade
  - 1.2 Steroid hormones (genomic and non genomic pathways)
2. Overview of Non - classical hormones
  - 2.1 Growth factors: cellular origin, secretion and functions
    - 2.1.1 Epidermal growth factor (EGF)
    - 2.1.2 Platelet-derived growth factor family
    - 2.1.3 Fibroblast growth factor family
    - 2.1.4 Insulin family (IGF-1 and IGF-II)
    - 2.1.5 Nerve growth factor

**UNIT-II**

3. Hypothalamo-hypophysial system
  - 3.1 General organization
  - 3.2 Chemistry and physiological role of :
    - 3.2.1 Hypophysiotropic hormones
    - 3.2.2 Neurohypophysial octapeptides
    - 3.2.3 Adenohypophysial hormones

**UNIT-III**

4. Pineal organ
  - 4.1 Structure of pinealocyte
  - 4.2 Indoleamines
    - 4.2.1 Synthesis and Control of secretion
    - 4.2.2 Physiological role of Melatonin (in reproduction, aging and immunity)
  - 4.3 Melatonin and biological rhythm
5. Adrenal gland
  - 5.1 Histology of mammalian adrenal gland
  - 5.2 Corticoids and their physiological role
  - 5.3 Catecholamines
    - 5.3.1 Biosynthesis, storage and secretion
    - 5.3.2 Physiological role

**UNIT-IV**

6. Endocrinology of mammalian Testis and Ovary
  - 6.1 Histology of Testis and Ovary
  - 6.2 Steroid chemistry and nomenclature
  - 6.3 Synthesis of gonadal steroids
  - 6.4 Physiological roles of androgen, estrogen and progesterone
  - 6.5 Relaxin, Inhibin and activins

Books recommended:

1. Norris: Vertebrate Endocrinology ( 2<sup>nd</sup> ed. 2007, Elseiver)
2. Bentley: Comparative Vertebrate Endocrinology (2000, Cambridge University Press)
3. Hadley, M.C.: Endocrinology (Edition, 2000, Prentice Hall, International)
4. Wilson and Foster, Williams Text Book of Endocrinology (10th edition, 2005 W.B. Saunders Company Philadelphia)
5. Gorbman et al: Comparative Endocrinology (John Wiley)

**Semester -II**  
M.Sc. Zoology  
**Paper VI. Immunology**

Max. Mark 50

UNIT- I

1. Immunity
  - 1.1 Components of Innate immunity
    - 1.1.1 Phagocytosis
    - 1.1.2 Inflammation
    - 1.1.3 Acute phase proteins
  - 1.2 Adaptive immunity
2. Cells and organs of immune system
  - 2.1. Lymphocytes (B- and T-lymphocytes, Natural killer cells/Null cells)
  - 2.2. Mononuclear Phagocytes
  - 2.3. Granulocytes (eosinophil, Neutrophil, Basophil and mast cells)
  - 2.4. Dendritic cells
  - 2.5. Lymphoid tissues/organs
    - 2.5.1. Primary (Bone marrow and thymus)
    - 2.5.2. Secondary (Lymph nodes, spleen)

UNIT- II

3. Antigens
  - 3.1. Immunogenicity vs antigenicity
  - 3.2. General properties of antigen
  - 3.3. B-cell and T-cell epitopes
  - 3.4. Haptens
4. Immunoglobulins
  - 4.1. Structure and function
  - 4.2. Classification
  - 4.3. Antigenic determinants on immunoglobulins

UNIT-III

5. Major Histocompatibility Complexes
6. Types of Immune response
  - 6.1. Humoral immune response
    - 6.1.1 Primary and secondary response
    - 6.1.2 Concept of clonal selection
    - 6.1.3 Class switching
  - 6.2. Cell mediated immune response
    - 6.2.1 Cytotoxic T lymphocyte and mechanism of cytotoxicity
    - 6.2.2 N K cells and mechanism of cytotoxicity

UNIT- IV

7. T-cell receptors
8. Vaccination
  - 8.1 Adjuvant
  - 8.2 Types of vaccines
9. Immune disorders

9.1 Autoimmune diseases (Organ specific and systemic)

9.2 Immunodeficiency (Primary and Secondary)

*Books recommended*

1. Abbas et al: Cellular and Molecular Immunology (2000, Saunders)
2. Elgert: Immunology understanding the Immune System (1996, Wiley)
3. Kuby: Immunology (6th ed 2007, Freeman)
4. Roitt: Essential Immunology (10th ed 2006, Mosby)
5. Roitt et al: Immunology (7th ed 2006, Mosby)
6. Khan : Elements of Immunology (2004, Pearson Publ.)

## Semester - II

### Practical I. Non chordata II and endocrinology

Max. Mark 50

Duration: 5 hrs

Dissection	..... 10
Preparation (Non chordate II)	..... 07
Endocrinology exercise	..... 08
Spots (5)	..... 10
Viva voce	..... 05
Records	..... 10

#### A. Non chordata

1. Study of slides and museum specimens of-
    - Annelida
    - Arthropoda
    - Mollusca
    - Echinodermata
  2. Preparation of permanent slides-
    - Statocyst of prawn
    - *Cyclops*,
    - *Daphnia*
    - Glochidium larva
    - Pedicellaria
    - Radula of Pila
  3. Dissection of-
    - Hastate plate in prawn
    - Nervous system of prawn
    - Alimentary canal of cockroach
    - Salivary gland of cockroach
    - Reproductive system of cockroach
    - Nervous system of Pila (demonstration only)
- #### B. Endocrinology
1. Study of the mammalian endocrine glands using permanent slides (pituitary, thyroid, pancreas, adrenal and gonads)
  2. Study of oestrous cycle of rat by vaginal smear preparation
  3. Reproductive organs of mice/rat

## Semester II

### Practical II. Biostatistics, histochemistry and immunology

Max. marks 50  
Duration: 5 hrs

Biostatistics	..... 20
Histochemistry	..... 07
Immunology	.....08
Viva voce	..... 05
Records	..... 10

#### A. *Biostatistics*

1. Numerical exercises based on:
  - Measures of central tendency
  - Measures of dispersion
  - Probability
  - Theoretical distributions
  - Test of significance
  - Correlation and Regression

#### B. *Histochemistry*

- Fixation of tissue (e.g. intestine and stomach of rat/mice)
- Dehydration, clearing and embedding of tissue block in paraffin
- Sectioning of paraffin blocks, stretching and spreading
- Histochemical staining of paraffin sections for carbohydrate using Periodic acid/Schiff's method (PAS reaction)
- Histochemical staining of Protein (Ninhydrin-Schiffs reaction)
- Histochemical staining for general lipid (Sudan Black B)

#### C. *Immunology*

1. Determination of Lymphocyte count in human blood
2. Determination of Monocyte count in human blood
3. Isolation and permanent preparation of peritoneal macrophage
4. Cell viability test (trypan blue)
5. NBT slide assay

### Practical III. Dissertation & Seminar

Max. Marks 50

Each student has to prepare a dissertation on semester based syllabus and present a seminar. This will be evaluated by a panel of internal examiners (time allotted for presentation is 45 minutes per student).

- Dissertation                      25 Marks
- Seminar                            25 Marks

**Semester III**  
M.Sc. Zoology  
**Paper I. Chordata I**

Max. Mark 50

UNIT –I

1. Origin of Chordata
2. General organization and affinities of
  - Hemichordata
  - Urochordata
  - Cephalochordata
3. Retrogressive metamorphosis in Urochordates

UNIT – II

1. General organization and affinities of Agnatha
2. General organization and affinities of
  - Elasmobranchii
  - Holocephali
  - Dipnoi
  - Crossopterygii

UNIT– III

3. Origin of tetrapoda
4. Neoteny and Paedogenesis in urodela
5. Parental care in Amphibia
6. Comparative anatomy of respiratory organs in Tetrapoda

UNIT– IV

7. Origin and evolution of reptiles
8. General organization, distribution and affinities of Rhynchocephalia and Crocodilia
9. Skull in reptiles

*Books Recommended*

1. Colbert et al: Colbert's Evolution of the Vertebrates: A history of the backboned animals through time (5th ed 2002, Wiley - Liss)
2. Hildebrand: Analysis of Vertebrate Structure (4th ed 1995, John Wiley)
3. Jordan and Verma: Chordate Zoology (1998, S. Chand)
4. Kotpal: The Birds (4th ed 1999, Rastogi Publications)
5. McFarland et al: Vertebrate Life(1979, Macmillan Publishing)
6. Parker and Haswell: TextBook of Zoology, Vol. II (1978, ELBS)
7. Romer and Parsons: The Vertebrate Body (6th ed 1986, CBS Publishing Japan)
8. Sinha, Adhikari and Ganguli: Biology of Animals, Vol. II (1988, New Central Book Agency)
9. Young: The life of vertebrates (3rd ed 2006, ELBS/Oxford)

**Semester - III**  
M.Sc. Zoology  
**Paper II. Animal Physiology**

Max. Mark 50

**UNIT-I**

1. Digestion

- 1.1 Digestion and absorption of carbohydrate, proteins and fat
- 1.2 Gastrointestinal hormones and their role in digestion

2. Circulation

- 2.1 Interrelationships among blood pressure, blood flow and resistance to blood flow
- 2.2 Cardiovascular control by nervous system in man
- 2.3 ECG
- 2.4 Myocardial infarction

**UNIT-II**

3. Respiration

- 3.1 Respiratory pigments
- 3.2 Factors affecting respiratory rates
- 3.3 Respiratory adjustments: Metabolic adaptations to Hypoxia
- 3.4 Respiratory buffering

**UNIT-III**

4. Excretion

- 4.1 General pattern of nitrogenous excretion (Ammonotelism, ureotelism, uricotelism and guanotelism)
- 4.2 Urea synthesis
- 4.3 Hormonal regulation of renal function
- 4.4 Renal regulation and Acid-base balance
- 4.5 Renal function tests

**UNIT-IV**

5. Muscle

- 5.1 Muscle proteins
- 5.2 Mechanism of contraction (Skeletal muscle)
- 5.3 Excitation–contraction coupling
- 5.4 Energetic of Muscle contraction
- 5.5 Role of Ca<sup>++</sup> in muscle contraction

6. Nerve transmission

- 6.1 Types of neurons
- 6.2 Axonal conduction
  - 6.2.1 Electrochemical potential and Nerst's equation
  - 6.2.2 Resting membrane potential and action potential
  - 6.2.3 Conduction of impulse
- 6.3 Synaptic transmission
  - 6.3.1 Electrical and chemical synaptic transmission
  - 6.3.2 Excitatory and inhibitory post-synaptic potential
- 6.4 Neurotransmitters



Books recommended:

1. Ganong: Review of Medical Physiology (22nd ed 2005, Lang Medical Publications)
2. Guyton and Hall: Text Book of Medical Physiology (11th ed 2006, W.B. Saunders)
3. Keel et al: Samson Wright's Applied Physiology (13th ed 1989, Oxford Press)
4. Murray et al: Harper's Illustrated Biochemistry (27th ed 1989, Appleton & Lange)
5. Randall, Burggren and French: Eckert Animal Physiology (4<sup>th</sup> ed. 1997, WH Freeman&Co.)
6. West: Best and Taylor's Physiological Basis of Medical Practice (11th ed 1981, Williams and Wilkins)

**Semester III**  
M.Sc. Zoology  
**Paper III. Developmental Biology**

Max. Mark 50

**UNIT-I**

1. Fertilization
  - 1.1 Recognition of gametes and acrosomal reaction
  - 1.2 Prevention of polyspermy
  - 1.3 Gamete fusion
  - 1.4 Activation of egg
2. Early development
  - 2.1 Cleavage: patterns and types
  - 2.2 Formation of blastula in amphibians
  - 2.3 Gastrulation: fate maps, cell movement and formation of germ layers in amphibians and birds

**UNIT-II**

3. Germ layers and their fate
4. Dependent differentiation
  - 4.1 General concept of potency, competence and interaction
  - 4.2 Organizer concept

**UNIT-III**

5. Cellular and hormonal events during metamorphosis in insects and amphibians
6. Regeneration
  - 6.1 Regeneration in invertebrates
  - 6.2 Regeneration in amphibian limb

**UNIT-IV**

3. Organogenesis of
  - 7.1 Vertebrate brain
  - 7.2 Vertebrate heart

*Books Recommended*

1. Alberts et al: Molecular Biology of the Cell (4th ed 2002, Garland)
2. Balinsky: An introduction to Embryology (5th ed 1981, Saunders)
3. Gilbert: Developmental Biology (8th ed 2006, Sinauers )
4. Kalthoff: Analysis of Biological development (1996, McGraw)
5. Wolpert: Principles of Development (3rd ed 2007, Oxford)

**Semester III**  
M.Sc. Zoology  
**Paper IV. Biotechnology**

Max. Mark 50

**UNIT-I**

1. Cell and tissue culture
  - 1.1 Primary and secondary cell culture and its medium
  - 1.2 Tissue and organ culture
  - 1.3 Cell culture based products
    - 1.3.1 Production of vaccines,
    - 1.3.2 Production of hormone (Insulin & glucagon)
2. Hybridoma technology
  - 2.1 Somatic cell fusion
  - 2.2 Selection of hybrids and hybridomas
  - 2.3 Application of monoclonal antibodies

**UNIT-II**

3. Recombinant DNA technology-I
  - 3.1 Restriction endonucleases
  - 3.2 Cloning vectors
    - 3.2.1 Plasmids and plasmid vectors,
    - 3.2.2 Phages and Phage Vectors,
    - 3.2.3 Phagemids,
    - 3.2.4 Cosmids,
  - 3.3 Electroporation, microinjection, microprojectile technology

**UNIT-III**

4. Recombinant DNA technology-II
  - 4.1 Molecular probe: production, labelling and uses
  - 4.2 Preparation and screening of cDNA and genomic DNA libraries
  - 4.3 Southern and Northern hybridizations
  - 4.4 *In situ* hybridization
  - 4.5 Polymerase chain reaction: principles and applications
  - 4.6 DNA fingerprinting, DNA foot printing

**UNIT-IV**

5. Gene silencing: RNA interference (RNAi).
6. Enzyme immobilization: method and applications; Application of enzyme engineering
7. Transgenic animals, genetic counselling

*Books Recommended*

1. Boyer: Modern Experimental Biochemistry and Molecular biology (2nd ed 1993, Benjamin/Cumin)
2. Freifelder: Physical Biochemistry ( 2nd ed 1982, Freeman)
3. Holme and Peck: Analytical Biochemistry ( 3rd ed 1998, Tata McGraw Hill)
4. Plummer: An Introduction to Practical Biochemistry (3rd ed 1990, Tata-McGraw Hill)
5. Switzer and Garrity: Experimental Biochemistry ( 92nd ed 1999, Freeman)

6. Wilson and Walker: Principles of Biochemical and Molecular Biological Techniques (6th ed 2006, Cambridge Univ Press)
7. Karp: Cell and Molecular Biology (2007, Wiley)
8. Ruthman: Methods in Cell Research (1970, Bell & Sons)
9. Bancroft & Stevens: Theory and Practice of Histological techniques (2002, Churchill-Livingstone)
10. Casselman: Histochemical techniques (1959, John Wiley)
11. Pearse: Histochemistry: Theoretical and Applied (Vol. I, II & III) (4th ed 1980-1993, Churchill-Livingstones)
12. Asubel et al: Current Protocol in Molecular Biology (1994, Wiley)

**Semester III**  
M.Sc. Zoology  
Special paper  
**Paper V. Fish Physiology**

Max. Mark 50

**UNIT-I**

1. Digestion
  - 1.1 Food and feeding habits
  - 1.2 Physiology of Digestion
2. Respiration
  - 2.1 Primary & secondary gill lamellae, circulation
  - 2.2 Mechanisms of gill ventilation
    - 2.2.1 Concurrent & Counter current principle
    - 2.2.2 Water flow across the gills
    - 2.2.3 Respiratory pump

**UNIT-II**

3. Excretion
  - 3.1 Pattern of nitrogenous wastes
    - 3.2.1 Uricogenolytic pathway of urea and urine formation
    - 3.2.2 Stenohaline teleosts
    - 3.2.3 Euryhaline teleosts
4. Osmoregulation
  - 4.1 Osmoregulatory organs (Rectal gland and gills)
  - 4.2 Osmoregulatory mechanism in fresh water and marine fishes
  - 4.3 Physiological adaptations in migratory fishes

**UNIT-III**

5. Swim bladder
  - 5.1 General organization and circulation
  - 5.2 Mechanism of gas secretion
  - 5.4 Functions of swim bladder
7. Reproduction:
  - 6.1 Gonadal steroidogenesis
  - 7.2 Gonadal steroid and their role in reproduction

**UNIT-IV**

7. Endocrines
  - 7.1 Hypothalamo-hypophyseal system
  - 7.2 Thyroid
  - 7.3 Ultimobranchials
  - 7.4 Cortical and medullary homologue
  - 7.5 Corpuscles of Stannius
  - 7.6 Urophysis
  - 7.7 Pineal

*Books Recommended*

1. Bentley: Comparative Vertebrate Endocrinology (2000, Cambridge University Press)

2. Bond: Biology of Fishes (1979, Saunders)
3. Brown: The Physiology of Fishes Vol I, II (1953 & 1957, Academic Press)
4. Evans: The Physiology of Fishes(1998, CRC Press)
5. Gorbman et al: Comparative Endocrinology (John Wiley)
6. Hoar & Randall: Fish Physiology, Series Vol. I – XIV (Academic Press)
7. Khanna and Singh: Textbook of Fish Biology and Fisheries (2003, Narendra Publishing House)
8. Nilsson & Holmgren: Fish Physiology Recent Advances (1986, Croom Helm)

**Semester III**  
M.Sc. Zoology  
Special paper  
**Paper VI. Applied Ichthyology (Culture Fishery)**

Max. Mark 50

UNIT-I

1. Fish Culture
  - 1.1 Fish farm
    - 1.1.1 Construction and lay out of different types of ponds
    - 1.1.2 Construction and operation of fish hatcheries
    - 1.1.3 Brood pond management for culturable indigenous and exotic carps
  2. Other systems of fish culture
    - 2.1 Fish culture in paddy fields
    - 2.2 Sewage-fed fisheries
    - 2.3 Cage, raft, pens, raceways

UNIT-II

3. Pond management
  - 3.1 Manuring (organic and inorganic) and liming
  - 3.2 Composite fish farming
  - 3.3 Predatory and weed fishes, their eradication
  - 3.4 Biological means of increasing fish production

UNIT-III

4. Induced breeding
  - 4.1 Factors responsible for induced breeding
  - 4.2 Stripping
  - 4.2 Hypophysation
  - 4.3 Use of different synthetic and natural hormones
  - 4.4 Bundh breeding
  - 4.4 Hapa breeding
  - 4.5 Hatchery breeding
- 2 Fish seed collection, transport of brood fishes and fish seed

UNIT-IV

6. Exotic fishes and their role in fish farming
7. Larvivorous fishes
8. Genetic manipulation and their significance in aquaplosion
  - 8.1 Hybridization
  - 8.2 Production of monosex and sterile fishes
  - 8.3 Transgenic fish
  - 8.4 Overview of fish genetics in India

*Books recommended*

1. Chakroff: Freshwater Fish Pond Culture and Management (1987, Scientific Publishers)
2. Hall: Ponds and Fish Culture (1994, Agro Botanical Publishers)

3. Hora and Pillay: Handbook on Fish Culture in the Indo-Pacific Region (1962, Fisheries Division, Biology Branch,,FAO)
4. . Huet: Textbook of Fish Culture, Breeding and Cultivation of Fish, Fishing News (1989, Books)
5. Khanna and Singh: Textbook of Fish Biology and Fisheries (2003, Narendra Publishing House)
6. Lagler: Studies in fresh water fishery biology (1950)
7. Rounsfell and Everhart: Fishery Science: It's Methods and Applications (1985, John Wiley)
8. Santhanam: Fisheries Science (1990, Daya Publishing House)
9. Pillay: Aquaculture: Principles and Practices: Fishing News Books: (2005, First Indian reprint)
- 10 .Gupta and Gupta: General and applied Ichthyology (Fish and Fisheries) (2006, Chand )
11. Srivastava: A Textbook of Fishery Science and Indian Fisheries (1985, Kitab Mahal)



## Semester III

### Practical I. Chordata I

Max. Mark 50  
Duration: 5 hrs

Dissection	..... 15
Preparation	..... 10
Spots (5)	..... 10
Viva voce	..... 05
Records	..... 10

Based on following Exercises:-

1. Study of slides and museum specimens of-
  - Protochordates
  - Balanoglossus
  - Fish
  - Amphibia
  - Reptiles
2. Preparation of permanent slides:-
  - Oral hood, velum and pharyngeal wall of *Branchiostoma*
  - Spicules of *Herdmania*
  - Placoid Scales
  - Chromatophores
3. Dissection and display of:-
  - Afferent and efferent branchial vessels of *Mystus*
  - Cranial nerves of *Mystus*
  - Eye muscle of *Mystus*
4. Study of Bones of Frog and Varanus

### Semester III

#### Practical II. Physiology & Developmental Biology

Max. Mark 50  
Duration: 5 hrs

Physiology	..... 20
Developmental Biology	..... 15
Viva voce	..... 05
Records	..... 10

#### A. Physiology

1. Determination of gonosomatic index and hepatosomatic index
2. Study of length-weight relationship of major carp and catfish
3. Detection of blood groups (A, B, O & Rh)
4. Preparation of haemin crystals
5. RBC count
6. Total WBC count
7. Differential WBC count
8. Estimation of Hb
9. Estimation of ascorbic acid content in lemon extract using titration method
10. Demonstration of pattern of nitrogenous waste excretion (NH<sub>3</sub>, urea, uric acid) in animals

#### B. Developmental Biology

1. Study of embryonic developmental stages in frog through slides and models
2. Study of embryonic development in chick through slides
3. Window preparation to study chick embryo development
4. Whole mount preparation of chick embryos at various stages of development

#### Practical III. Dissertation & Seminar

Max. Marks 50

Each student has to prepare a dissertation on semester based syllabus and present a seminar. This will be evaluated by a panel of internal examiners (time allotted for presentation is 45 minutes per student).

- |                |          |
|----------------|----------|
| - Dissertation | 25 Marks |
| - Seminar      | 25 Marks |

**Semester IV**  
M.Sc. Zoology  
**Paper I. Chordata II**

Max. Mark 50

UNIT – I

1. Origin of birds
2. Adaptation of aerial mode of life
3. Aquatic adaptations in birds
4. Flightless birds
5. Bird migration

UNIT – II

6. Origin of mammals
7. General organization and distribution of prototheria and metatheria
8. Adaptive radiation in eutherians

UNIT – III

9. Placentation in mammals
10. Dentition in mammals
11. Integuments and its derivatives

UNIT – IV

12. Comparative anatomy of brain in vertebrates
13. Evolution of heart, aortic arches and portal system in vertebrates
14. Evolution of urinogenital system in vertebrates

*Books Recommended*

1. Colbert et al: Colbert's Evolution of the Vertebrates: A history of the backboned animals through time (5th ed 2002, Wiley - Liss)
2. Hildebrand: Analysis of Vertebrate Structure (4th ed 1995, John Wiley)
3. Jordan and Verma: Chordate Zoology (1998, S. Chand)
4. Kotpal: The Birds (4th ed 1999, Rastogi Publications)
5. McFarland et al: Vertebrate Life(1979, Macmillan Publishing)
6. Parker and Haswell: TextBook of Zoology, Vol. II (1978, ELBS)
7. Romer and Parsons: The Vertebrate Body (6th ed 1986, CBS Publishing Japan)
8. Sinha, Adhikari and Ganguli: Biology of Animals, Vol. II (1988, New Central Book Agency)
9. Young: The life of vertebrates (3rd ed 2006, ELBS/Oxford)

**Semester IV**  
M.Sc. Zoology  
**Paper II. Animal Behaviour**

## UNIT-I

Max. Mark 50

## 1. Introduction to Ethology

- 1.1 Behaviour, phenotypic traits among species
- 1.2 Interactions among species (parasitism, mutualism, commensalism and mimicry)

## 2. Behavioural patterns:

- 2.1 Innate and learned behaviour
- 2.2 Environmental influence upon behaviour

## UNIT-II

## 3. Reproductive behaviour

- 3.1 Copulatory pattern: Proceptive and receptive behaviour
- 3.2 Courtship and mating
- 3.3 Role of hormones in reproductive behaviour

## UNIT-III

## 4. Animal learning

- 4.1 Conditioning and Associative learning
- 4.2 Trial & error
- 4.3 Imprinting and Habituation

## 5. Communication among animals

- 5.1 Evolution of animal signals
- 5.2 Chemical communication (Pheromones)
  - 5.2.1 Male induction of estrus (Whitten effect)
  - 5.2.2 Male induced pregnancy block (Bruce effect)
- 5.3 Communication in honey bees

## UNIT-IV

## 6. Social organization

- 6.1 Social competition and dominance hierarchies
- 6.2 Territoriality in birds
- 6.3 Altruism in eusocial animals
- 6.4 Social organization in honey bee

*Books Recommended*

1. Alcock : Animal Behaviour: An Evolutionary Approach (7th ed 2005, Sinaur)
2. Bolhuis & Giraldeau: The Behavior of Animals: mechanisms, function, and evolution (2005, Blackwell)
3. Drickamer & Vessey: Animal Behaviour –Concepts, Processes and Methods (2nd ed 1986, Wadsworth)
4. Drickamer, Vessey & Jakob: Animal Behavior: Mechanisms, Ecology, Evolution (2007, McGraw-Hill)
5. Gadagkar: Survival Strategies: Cooperation and Conflict in Animal Societies. (1998, Univ. Press)

6. Goodenough et al: Perspectives on Animal Behaviour (1993, Wiley)
7. Grier: Biology of Animal Behaviour (1984, Mosby)
8. Krebs & Davis: Behavioural Ecology. (3rd ed 1993, Blackwell)
9. Lehner: Hand Book of Ethological Methods.(2nd ed 1996, Garland)
10. Manning & Dawkins: An introduction to Animal Behaviour (5th ed 1998, Cambridge Univ. Press)
11. Slater & Halliday: Behaviour and Evolution (1st ed 1994, Cambridge Univ. Press)

**Semester -IV**  
M.Sc. Zoology  
Special Paper  
**Paper III. Fish Anatomy**

Max. Mark 50

**UNIT-I**

1. Integument
  - 1.1 Epidermis
    - 1.1.1 Mucogenic
    - 1.1.2 Keratinized
  - 1.2 Dermis
    - 1.2.1 General organization
    - 1.2.2 Scales
    - 1.2.3 Chromatophores
- 5 Tail and fins: Types & modifications

**UNIT-II**

3. Nervous system
  - 3.1 Brain and cranial nerves
  - 3.2 Receptors
    - 3.2.2 Acoustico-lateralis system
      - 3.2.2.1 Membranous Labyrinth
      - 3.2.2.2 Lateral line organs
    - 3.2.3 Chemoreceptors
      - 3.2.3.1 Gustatory
      - 3.2.3.2 Olfactory
    - 3.2.4. Electroreceptors
4. Weberian ossicles and its function

**UNIT-III**

5. Structure of gills and gill rakers, function of gill rakers
6. Alimentary canal and its modifications in relation to food and feeding habits
7. Air-breathing fishes
  - 7.1 Accessory respiratory organs and respiratory epithelium
  - 7.2 Adaptation in air-breathing fishes

**UNIT-IV**

8. Heart and aortic arches
9. Kidney structure and modifications
10. Specialized organs
  - 10.1 Sound producing organ
  - 10.2 Electric organ

*Books recommended*

1. Jhingran: Fish and Fisheries of India (1985, Hindustan Publishing Corporation)
1. Bond: Biology of Fishes (1979, Saunders)
2. Lagler, Bardach, Miller and May Passino: Ichthyology (2003, John Wiley)
3. Datta-Munshi & Hughes: Air-breathing fishes of India (1992, Oxford and IBH)
4. .Gupta and Gupta: General and applied Ichthyology (Fish and Fisheries) (2006, Chand )
5. Pandey & Shukla: Fish and Fisheries (Rastogi Publ.)
6. Khanna and Singh: Textbook of Fish Biology and Fisheries (2003, Narendra Publishing House)

**Semester IV**  
M.Sc. Zoology  
**Paper IV. Fish Taxonomy**

Max. Mark 50

UNIT-I

1. Relevance of fish systematics
2. Fish diagnostics
3. Fish collection
4. Field notes and labelling

UNIT-II

5. History of fish taxonomy
6. Rules of Nomenclature
7. Law of priority
8. Synonyms and homonyms

UNIT-III

9. Types of concept for
  - 9.1 Fish genera
  - 9.2 Fish species
  - 9.3 Definition regarding selection of types
  - 9.4 Identification of some local forms (5 types upto species)

UNIT-IV

10. Description of fish taxa
  - 10.1 Preparation of identification key
  - 10.2 Dichotmous keys
  - 10.3 Group or box keys
  - 10.4 Pictorial keys
11. Characterization
  - 11.1 Description of old species
  - 11.2 Description of new species

*Books Recommended:*

1. Mishra: Records of Indian Museum: an aid to the identification of the common commercial fishes of India and Pakistan Vol 5 (Part I-IV) (1962)
2. Srivastava, Gopalji: Fishes of U.P. and Bihar (2002, Vishwavidyalaya Prakashan)



**Semester - IV**  
M.Sc. Zoology  
**Paper V. Fish Ecology and Fish Pathology**

Max. Mark 50

**UNIT-I**

1. Abiotic factors
  - 1.1 Physico-chemical properties of pond water and soil
    - 1.1.1 Temperature
    - 1.1.2 Salt content
    - 1.1.3 Suspended particles
    - 1.1.4 Bottom deposits
2. Biotic factors
  - 2.1 Interrelationship among fishes and with other organism
  - 2.2 Role of plankton in relation to fish production
  - 2.3 Aquatic vegetation and its control

**UNIT-II**

3. Aquatic pollution
  - 3.1 Source and Hazards (Agricultural run off, Sewage and Industrial effluents)
  - 3.2 BOD & COD
  - 3.3 Pollution diseases
  - 3.4 Pollution Control measures

**UNIT-III**

4. Adaptations to different modes of life
  - 4.1 Deep sea fishes
  - 4.2 Hill stream fishes
5. Fish migration

**UNIT-IV**

6. Fish pathology, prophylaxis and therapy
  - 6.1 Protozoan diseases of fish
    - 5.1.1 Cyclochaetiasis, Costiasis, (sliminess of skin)
    - 5.1.2 Ichthyophthiriasis (white spot disease)
  - 6.2 Helminth parasites of fish
    - 5.2.1 *Gyrodactylus*
    - 5.2.2 *Dactylogyrus*
  - 6.3 Crustacean parasites of fish
    - 5.3.1 *Lernaea*
    - 5.3.2 *Ergasilus*
  - 6.4 Fungal diseases of fish
    - 5.4.1 Saprolegniasis
    - 5.4.2 Branchiomycosis (gill rot)
  - 6.5 Bacterial diseases of fish
    - 5.5.1 Tail and fin rot

- 5.5.2 Dropsy
- 5.5.3 Furunculosis
- 6.6 Viral diseases of fish
  - 6.6.1 Papillomatosis (cauliflower disease)
  - 6.6.2 Pox disease

*Books recommended*

1. Jhingran: Fish and Fisheries of India (1985, Hindustan Publishing Corporation)
2. Khanna and Singh: Textbook of Fish Biology and Fisheries (2003, Narendra Publishing House)
3. Ribelin & Migaki: The Pathology of Fishes (1975, The Univ. of Wisconsin Press)
4. Davis: Culture and Diseases of Game Fishes (1956, University of California Press)
5. Duijn: Diseases of Fishes (1967, London Iliffe Books)

**Semester IV**  
M.Sc. Zoology  
**Paper VI. Applied Ichthyology (Capture Fishery)**

Max. Mark 50

UNIT –I

1. The inland capture fishery resources of India
  - 1.1 Riverine fisheries
    - 1.1.1 Riverine fisheries resources
    - 1.1.2 Regulation and exploitation
    - 1.1.3 Improvement of fish stocks
    - 1.1.4 Dams and their effect on fish migration and remedial measures
  - 1.2 Cold water fishery: management, development and exploitation

UNIT-II

2. Estuarine fisheries: management, development and exploitation
3. Marine fishery: exploitation of marine fishery resources of India

UNIT-III

4. Fishing gears and fishing methods
  - 4.1 Biological factors in fishing
  - 4.2 Types of fishing gears
  - 4.4 Preparation and maintenance of fishing nets
5. Importance and methods of fish preservation
 

5.1 Refrigeration and freezing	5.4 Smoking
5.2 Drying	5.5 Canning
5.3 Salting	5.6 Pickling, pasting and spicing

UNIT-IV

6. Fish Marketing
7. Fishery by-products, their production and utilization
 

6.1 Liver oils	6.7 Fish glue
6.2 Body oils	6.8 Isinglass
6.3 Fish meal	6.9 Chitin
6.4 Fish flour	6.10 Surgical suture from fish gut
6.5 Fish silage	6.11 Ambergris
6.6 Bone meal	

*Books Recommended*

1. Howard & Churchill Canning technology (London)
2. Khanna and Singh: Textbook of Fish Biology and Fisheries (2003, Narendra Publishing House)
3. Kreuzer: Fishery products, FAO, Fishing News (1974, Books)
4. Lagler: Studies in fresh water fishery biology (1950)
5. Lagler, Bardach, Miller and May Passino, Ichthyology (2003, John Wiley)
6. Rounsfell and Everhart: Fishery Science: It's Methods and Applications (1985, John Wiley)
7. Santhanam: Fisheries Science (1990, Daya Publishing House)
8. The Wealth of India, Raw Materials Vol IV Fish and Fisheries (1962, CSIR)
9. Pillay: Aquaculture: Principles and Practices: Fishing News Books: (2005, First Indian reprint)
10. Gupta and Gupta: General and applied Ichthyology (Fish and Fisheries) (2006, Chand )

## Semester IV

### Practical I. Chordata II and Taxonomy of Fish

Max. Mark 50  
Duration: 5 hrs

Dissection	..... 08
Preparation/Minor Dissection	..... 05
Taxonomy	.....08
Spots (7)	..... 14
Viva voce	..... 05
Records & Collection	..... 10

#### A: Fish Taxonomy

1. Collection and Identification of some local fresh water fishes.
2. Identification of some marine fishes having specialised organs viz. electric organs, venomous organs, brood pouch, and deep sea fishes.

#### B: Higher Chordata

1. Study of slides and museum specimens of-
  - Birds
  - Mammals
2. Study of bones of fowl and rabbit
3. Dissection of-
  - Flight muscle of pigeon
  - Urino-genital systems of rat
  - Neck nerve of rat
  - Collumela in bird
  - Ear ossicle
  - Pecten in bird

## Semester IV

### Practical II: Fish anatomy and ecology

Max. Mark 50

Duration: 5 hrs

Dissection	..... 10
Minor dissection / Preparation	..... 07
Ecology	.....08
Spots (5)	..... 10
Viva voce	..... 05
Records	..... 10

#### A. Fish Anatomy

1. Dissection showing accessory respiratory organ of-
  - 1.1 *Clarias batrachus*
  - 1.2 *Heteropneustes fossilis*
2. Dissection of *Labeo* showing gas bladder and Weberian ossicles
3. Dissection of *Labeo and Wallago* showing afferent, efferent branchial vessels and cranial nerves.
4. Dissection of *Labeo* to show various endocrine glands.
5. Preparation of permanent stained slides of scales and fish chromatophore
6. Study of gill and tail in fishes.
7. Study of prepared slides of scroll valve in shark, scales, testis, ovary, pituitary

#### B. Fish Ecology

1. Study of ecological adaptations in electric ray, sucker fish, flying fish, seahorse, puffer fish, deep sea fish, hill stream fish.
2. Analysis of physico-chemical properties of pond water- pH, TDS, CO<sub>2</sub> content (acidity), alkalinity (Phenolphthalein and methyl orange), O<sub>2</sub> content (Winkler's method), hardness (total, temporary and permanent), and turbidity
3. Study of locally available weed and predatory fishes
4. Study of fishing net
5. Study of planktons in the sample of fresh water.

## Semester IV

### Practical III. Dissertation & Seminar

Max. Marks 50

Each student has to prepare a dissertation on semester based syllabus and present a seminar. This will be evaluated by a panel of internal examiners (time allotted for presentation is 45 minutes per student).

- Dissertation	25 Marks
- Seminar	25 Marks